Chapter 8. Summary of NIS in Prince William Sound and Alaska

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8A. Purpose

To summarize our knowledge of marine NIS in Prince William Sound specifically and Alaska generally, we extracted information obtained from the literature, our field surveys, focal taxonomic research by systematists, and analysis of existing specimens in museum and reference collections (see detailed reports in Chapt 9). Because prior ecological and systematic work in Alaska has not focused on NIS, we also wish to establish a baseline for the status of NIS in Alaskan waters, against which future introductions may be measured. We partitioned the species records into 5 categories:

(1) Definite & probable NIS, along with particularly suspicious cryptogenic species;
(2) Cryptogenic species;
(3) New, undescribed species discovered by this study.
(4) Species with range extensions into south central Alaska discovered by this study; and
(5) Species that were reported/suspected as NIS, but which we dismissed upon further analysis.

The sudden appearance of apparently new or undescribed species in an ecosystem is often a good indicator of a biological invasion. Similarly, analysis of species' range extensions is an important tool in detecting NIS, which may be introduced from distant biogeographic provinces or from adjoining provinces. However, where the native biota is as poorly studied as in Alaska, it may be difficult to distinguish NIS from native species that are new to science, or from new records of species within their normal range. Discovery of undescribed species and range extensions needs to be evaluated in the context of other indicators of biological invasions, such as association with sites of human activities and particular transport mechanisms. Thus, designating species as native or NIS requires a series of graded criteria (see Methods below), but the origin of many species may remain unknown, i.e., "cryptogenic". These cryptogenic species may be further categorized into species that have particular, suspicious attributes in some criteria, or species that have not received adequate research to evaluate their origin. In other cases, species initially may be designated or suspected as NIS, but further consideration by experts may refute the initial concern.

8B. Methods

The graded criteria (derived from J.T. Carlton, e.g., Carlton 1979a, Chapman & Carlton 1991) used to determine whether each species in our database is introduced, native, or cryptogenic are described below. "Cryptogenic species" cannot be identified clearly as native or introduced, and thus have unknown origin (Carlton 1996). In Alaska, the marine biota in many groups have received little systematic and biogeographic analysis, and a large portion of species in these groups may be cryptogenic in origin due to lack of study without particular suspicions of invasive characteristics. Further discussion of criteria for identifying species as introductions are given in Chapman (1988), Chapman and Carlton (1991) and Eno (1996). Often a single criterion is not sufficient to designate a species as being introduced, but combinations of several factors

increase the probability of an accurate reconstruction of introductions and invasions. In several cases, we have indicated cryptogenic species that have some suspicious characteristics of NIS.

- Paleontological - NIS are absent from fossil record even though they are present in other locations; native species are found locally as recent fossils; cryptogentic species are not in the local fossil record, but they are not reliably fossilized generally.
- Archeological - NIS are absent from shell middens and other archeological deposits; native species are in local deposits; cryptogenic species would not be expected to be found in archeological deposits.
- Historical - NIS are not recorded by direct observation at early periods, especially by trained naturalists, but suddenly appear where trained observers did not find them previously; native species are recorded in the earliest observations of trained observers; cryptogenic species are species that were not studied by early trained observers.
- Biogeographic - NIS exhibit grossly disjunct patterns of distribution (we took care to evaluate artifacts of the distribution of biologists/taxonomists); native species have continuous geographic ranges which include Alaska/Prince William Sound or other high latitudes; cryptogenic species have poorly known distributions or "cosmopolitan" distributions.
- Ecological - NIS have habitats in close association with other NIS (co-evolved species; specialized predator-prey, commensal or host-parasite relations); native species are closely associated with other native species; cryptogenic species are more generalized, lacking close, specialized association with other species.
- Dispersal Mechanisms - NIS presence cannot be plausibly explained by natural dispersal mechanisms and have documented human-mediated mechanisms which could effect their distributions; native species have natural dispersal mechanisms and lack known human-mediated mechanisms of introduction; cryptogenic species have both natural and human-mediated mechanisms of dispersal that could account for their distribution.
- Evolutionary/Genetic - NIS have isozyme or DNA frequencies which match distant proposed source populations and are significantly different from adjacent natural populations; native species have population genetics which blend with adjacent natural populations; cryptogenic species have not been studied with molecular techniques.

We also researched all published and anecdotal reports of NIS or range extensions of species that we were able to find in the scientific and informed popular literature for the region. We use these reports interactively with our field and museum work, both to direct our field surveys and re-examination of existing collections, and to determine the history of suspicious species that we collected in the field.

8C. Results

A diverse array of 24 species of plants and animals has been introduced into Alaskan waters, with 15 of these species being recorded in Prince William Sound (Table 8.1; see also Species Notes below). Of these definite/probableNIS, we collected 12 species in our Focal Taxonomic Analyses (Chapt 9), including 5 species of algae (*Ceramium sinicola*, *Croodactylon ramosum*, *Fucus cottoni*, *Macrocystis integrifolia*, *Codium fragile tomentosoides*), 1 species of sponge (*Cliona thosina*), 1 hydroid at Homer (*Garveia franciscana*),1 polychaete worm (*Heteromastus filiformis*), 2 molluscs (*Mya arenaria*, *Crassostrea gigas*), 1 bryozoan (*Schizoporella unicornis*), and 1 tunicate (*Botrylloides violaceus*). Our findings include 7 “first

TABLE 8.1 Definite/Probable NIS for Alaska * **Found by this project**

Species	Common Name	Probable Region of Origin	AK Regions	Date 1st Record	Invasion Status	Population Status	Ecological Impacts?	References
Rhodophyta								
* *Ceramium sinicola*	a red alga	NE Pacific (CA)	Prince William Sound	1998	Probable	Established	Fouling	Hansen 1998
* *Chroodactylon ramosum*	a red alga	NW Pacific	Prince William Sound	1998	Probable	Established	Fouling	Hansen 1998
Phaeophyta								
* *Fucus cottoni (=muscoides)*	a rockweed	NE Atlantic	Prince William Sound; Kenai Peninsula		Probable	Established	Unknown	Hansen 1998; South and Tittley 1986
* *Macrocystis integrifolia*	a kelp	NE Pacific (SE AK)	Prince William Sound	1979	Definite	Not reproducing	NIS vector	Hansen 1998
* *Microspongium globosum*	a brown alga	NW Pacific	Prince William Sound	1998	Probable	Established	Fouling	Hansen 1998
Sargassum muticum	Japanese brown alga	NW Pacific	SE Alaska	<1986	Definite	Established	Fouling	Scagel et al. 1986; USGS 1998
Chlorophyta								
* *Codium fragile (ssp. tomentosoides?)*	Dead Man's Fingers	(NW Pacific?)	Prince William Sound	1998	Probable	Established	Fouling	Hansen 1998
Angiospermophyta								
Cotula coronopifolia	Brassbuttons	S. Africa	SE Alaska (FW)	<1948	Definite	Established	Competitor?	Hulten 1968; USGS 1998
Sacodina-Foraminifera								
Trochammina hadai	a foraminiferan	NW Pacific	Prince William Sound	1989?	Definite	Established	Benthic processes	Cohen and Carlton 1995; McGann and Sloan 1996; McGann 1998 pers. comm
Porifera								
* *Cliona thosina*	a boring sponge	Unknown	Prince William Sound	1998	Probable	Established	Oyster shell damage	Ruetzler 1998 pers. comm.
Cnidaria-Hydrozoa								
* *Garveia franciscana*	Rope Grass Hydroid	Unknown	Homer	1999	Definite	Established	Fouling	Henry 1999 pers. comm.
Annelida- Polychaeta								
* *Heteromastus filiformis*	a capitellid polychaete	N Atlantic?	Prince William Sound	1998	Probable	Established	Competitor?	Jewett 1998; Cohen & Carlton 1995, Feder & Jewett 1973
Lumbrineris heteropoda	a lumbrinereid polychaete	NW Pacific (Japan-Sakhalin)	Resurrection, Glacier Bays	1979	Probable	Unknown?	Unknown?	Feder et al. 1979; Foster 1999 pers. comm., UA
Mollusca- Bivalvia								
* *Crassostrea gigas*	Pacific Oyster	NW Pacific	SE Alaska; Prince William Sound	1980s?	Definite	Not reproducing	NIS vector	Quayle 1969; Hines, 1998 pers. obs
* *Mya arenaria*	Softshell Clam	NW Atlantic; Bering Sea	SE Alaska; Prince William Sound	1800s?	Definite	Established	Competitor?	Baxter 1971; Feder & Paul 1973; Carlton 1979;
Crustacea-Amphipoda								
* *Jassa sp. / Jassa marmorata?*	a tube-dwelling amphipod	NW Atlantic	Prince William Sound	1999	Probable	Unknown?	Unknown	Chapman 1999 pers. comm.
Bryozoa								
Cryptosula pallasiana	a bryozoan	N Atlantic	SE Alaska (Sitka?)	1944-1946	Definite	Unknown?	Fouling	U.S. Navy 1951; Carlton 1999 pers. comm.; Dick & Ross 1988; Powell 1970
* *Schizoporella unicornis*	a bryozoan	NW Pacific	Kodiak, Prince William Sound	1944-1949	Definite	Established	Fouling	U.S. Navy 1951; Carlton, pers. comm.; Winston 1999 pers. comm.; Powell 1970; Dick & Ross 1988
Echinodermata-Ophiuroida								
Ophiothrix koreana	a brittlestar	NW Pacific	SE Alaska (Juneau)	1998	Definite	Unknown	Unknown	Kyte 1998 pers. comm.

TABLE 8.1 continued

Species	Common Name	Probable Region of Origin	AK Regions	Date 1st Record	Invasion Status	Population Status	Ecological Impacts?	References
Chordata- Ascidiacea								
***** *Botrylloides violaceus* **(=*Botrylus aurantius*)**	a tunicate	NW Pacific	Prince William Sound	1999	Definite	Established	Fouling	G.Lambert 1999pers.comm.
Chordata-Osteichthyes								
Alosa sapidissima	American Shad	NW Atlantic	N to Cook Inlet; Kodiak I.	1896	Definite	Migrant	Predator on salmonid fry?	Chapman 1942; McPhail and Lindsey 1986; USGS 1999
Dallia pectoralis (FW)	Alaska Blackfish	Arctic Slope (FW)	Anchorage area (FW)	1950s	Definite	Established	Predator on salmonid fry?	Morrow 1980; USGS 1999
Esox lucius (FW)	Northern Pike	Northern N. America (FW)	Anchorage area (FW)	1970s	Definite	Established	Predator on salmonid fry?	Morrow 1980; USGS 1999
Salmo salar	Atlantic Salmon	N Atlantic (Anadromous)	SE Alaska-Prince William Sound	1990	Definite	Unknown	Predator/ competitor of salmonids	Wing et al. 1992; Freeman 1998 pers. comm.; USGS 1999
Salvelinus fontinalis (FW)	Brook Trout	Eastern N. America (FW)	SE Alaska	1920	Definite	Established	Predator on salmonid fry?	Morrow 1980; Alaska Department of Fish and Game 1994; USGS 1999

records" for NIS in the region. Our Rapid Community Assessment (Chapt 9) found 1 NIS species (the soft-shelled clam *Mya arenaria*) to be widely distributed in intertidal sediments throughout Prince William Sound and the Kenai Peninsula. Two species (the oyster *Crassostrea gigas*, and the kelp *Macrocystis integrifolia*) are not established as self-sustaining, reproducing populations within the Sound; but these aquaculture introductions are being sustained by on-going inputs that serve as a potentially important mechanism of transport for many other associated species. Further notes on each of these NIS are provided below.

The literature reports 11 other NIS species, including 1 algal species (*Sargassum muticum*), 1 marsh plant (*Cotula coronopifolia*), 1 foraminiferan (*Trochammina hadai*), an amphipod crustacean (*Jassa marmorata*), 1 bryozoan (*Cryptosula pallasiana*), 1 brittle star (*Ophiothrix koreana*), and 5 species of fish (*Alosa sapidissima*, *Dallia pectoralis*, *Esox lucius*, *Salmo salar*, *Salvelinus fontinalis*). Several of these fish species were intentionally introduced in fresh water to augment fisheries, and we have included them here because they potentially have important impacts on native salmonid species in the region. Further notes on each of these NIS are provided below.

In addition, we consider two cryptogenic species to be particularly suspicious as NIS, because of their new appearance at harbor areas (i.e., Homer, Cordova)(Table 8.2). These species include a sea star (*Asterias amurensis*) that is native to Alaska in the Bering Sea, but which has a history of invading other regions (probably via ballast water transport), and which appears to have suddenly extended its range to Homer in south central Alaska. Despite surveys of the area by good naturalists, this large animal has not been recorded at Homer/Katchemak Bay until now. We also discovered a new, undescribed species of ascidian (*Dispalia* sp. nov.) in the fouling communities of Homer and Cordova, but it was not present at other locations with rich fouling communities but lacking intense boat/ship traffic. Further notes on each of these suspicious species are provided below.

A large portion of Alaskan marine species is cryptogenic in origin due to inadequate biogeographic and taxonomic study. However, many cryptogenic species also either exhibit wide distributions that may reflect global spread by early shipping traffic (Carlton 1996) or have other suspcicious traits of NIS (Table 8.3). During this project we collected at least 24 such species in Prince William Sound, and identified at least 5 others found elsewhere in Alaska.

During our study we discovered several apparently new/undescribed species (Table 8.4) and documented range extensions for many other species. (Table 8.5), which also highlights the need for more analysis of Alaskan marine biodiversity. We found specimens of 10 apparently new/undescribed species in Prince William Sound, including 1 brown alga, 6 polychaete worms, 2 molluscs, and 1 tunicate (Table 8.4). Formal species description of the tunicate species (*Distaplia* sp. nov.) is proceeding. We documented range extensions or first records for Prince William Sound or Cook Inlet (although some are known in the Bering Sea and further north) for 74 species (4 algae, 11 hydrozoan cnidarians, 2 ctenophores, 24 polychaete worms, 20 molluscs, 7 crustaceans, 2 bryozoans, 1 echinoderm, 2 tunicates, and 1 fish) (Table 8.5).

TABLE 8.2 Highly Suspicious Cryptogenic Species * **Found by this project**

Species	Common Name	Probable Region of Origin	AK Regions	Date 1st Record	Invasion Status	Population Status	Ecological Impacts?	References
Echinodermata - Asteroidea								
* *Asterias amurensis*	Asian Sea Star	NW Pacific; Bering Sea	Homer Spit	1999	Suspicious Range extension	Established	Predator on molluscs & other inverts	Baranova 1976; Ward and Andrew 1995; Foster et al. 1999 (Chapt 9, this report)
Chordata - Ascidiacea								
* *Distaplia* sp. nov.	a tunicate	unknown	Homer, Prince William Sound (Cordova)	1998	Suspicious New	Established	Fouling	G.Lambert 1999 pers. comm.

TABLE 8.3 Examples of Cryptogenic Species

Species	Common Name	Probable Region of Origin	AK Regions	Date 1st Record	Invasion Status	Population Status	Ecological Impacts?	References
Rhodophyta								
Porphyra miniata	a red alga	?	Prince William Sound	1998	Cryptogenic	Established	Unknown	Hansen 1998
Phaeophyta								
Demaraeaea attenuata	a brown alga	NW Pacific?	Prince William Sound	1998	Cryptogenic	Established	Unknown	Hansen 1998
Punctaria latifolia		NE Pacific?	Prince William Sound	1998	Range extension			Hansen 1998
Punctaria plantaginea	a brown alga	?	Prince William Sound	1998	Cryptogenic	Established	Unknown	Hansen 1998
Heterokontophyta-Xanthophycaeae								
Vaucheria longicaulis	a golden-brown alga	NE Pacific?	Prince William Sound	1998	Range extension, overlooked			Hansen 1998
Chlorophyta								
Blidingia marginata	a green alga	NE Pacific?	Prince William Sound	1998	Cryptogenic	Established	Unknown	Hansen 1998
Caposiphon fulvescens	a green alga	NE Pacific?	Prince William Sound	1998	Cryptogenic	Established	Unknown	Hansen 1998
Halochlorococcum moorei	a green alga	NE Pacific?	Prince William Sound	1998	Cryptogenic	Established	Unknown	Hansen 1998
Kornmannia leptoderma non *zostericola*	a green alga	NE Pacific?	Prince William Sound	1998	Cryptogenic	Established	Unknown	Hansen 1998
Angiospermophyta								
Atriplex patula (=A. p. var. *littoralis)*	Orach; Spearscale	Eurasia?	SE Alaska	1883	Cryptogenic	Established	Unknown	Meehan 1884; Hulten 1968
Atriplex prostrata (=A. patula var. *hastata)*	Halberd-Leaved Orach	Eurasia?	SE Alaska	?	Cryptogenic	Established	Unknown	Hulten 1968
Cnidaria								
Protohydra sp.	a worm-like hydroid	Cosmopolitan? (CA-BC)	Prince William Sound		Cryptogenic	Established	Unknown	Kozloff 1987; Foster 1999 pers. comm.; UAF collections
Annelida- Polychaeta								
Barantolla (americana species complex?)	a capitellid polychaete	Circumboreal?	Prince William Sound	1988	Cryptogenic	Established	Unknown	Kozloff 1987; Kudenov 1998, pers. comm.
Amphitrite (cirrata species complex?)	a terebellid polychaete	Circumboreal	Prince William Sound	1998	Cryptogenic	Established	Unknown	Kozloff 1987; Kudenov 1998, pers. comm.
Capitella (capitata? species complex?*)*	a capitellid polychaete	Cosmopolitan	Prince William Sound	1980	Cryptogenic	Established	Unknown	Jewett 1998; Cohen and Carlton 1995; Kudenov 1998, pers. comm.
Decamastus sp.	a capitellid polychaete	Cosmopolitan? (WA-BC)	Prince William Sound	1998	Cryptogenic	Established	Unknown	Jewett 1998; Kozloff 1987; Cohen and Carlton 1995
Eteone (longa species complex?*)*	a phyllodocid polychaete	Circumboreal	Prince William Sound	1980	Cryptogenic	Established	Unknown	Pettibone 1963; Kozloff 1987; Kudenov 1998, pers. comm.
Eumida (sanguinea species complex?*)*	a phyllodocid polychaete	Circumboreal	Prince William Sound	1998	Cryptogenic	Established	Unknown	Kozloff 1987; Kudenov 1998, pers. comm.
Harmathoe (imbricata species complex?)	a polynoid polychaete	Circumboreal	Prince William Sound	1980	Cryptogenic	Established	Unknown	Kozloff 1987; Cohen and Carlton 1995; Kudenov 1998, pers. comm.
Mediomastus sp.	a capitellid polychaete	Cosmopolitan	Prince William Sound	1988	Cryptogenic	Established	Unknown	[Jewett 1998]; Cohen and Carlton 1995
Pholoe (minuta species complex?)	a sigalionid polychaete	Circumboreal	Prince William Sound	1979	Cryptogenic	Established	Unknown	Jewett 1998; Cohen and Carlton 1995; Kudenov 1998, pers. comm.
Polydora quadrilobata	a spionid polychaete	NE Pacific (British Columbia)	Prince William Sound	?	Cryptogenic	Established	Unknown?	Kozloff 1987; Foster 1999 pers. comm.; UAF collections

TABLE 8.3 continued

Species	Common Name	Probable Region of Origin	AK Regions	Date 1st Record	Invasion Status	Population Status	Ecological Impacts?	References
Crustacea- Copepoda								
Leimia vaga	a harpactacoid copepod	NW Atlantic?	Prince William Sound	1999	Cryptogenic	Established	Unknown	Cordell 1999 pers. comm.
Mollusca- Bivalvia								
Macoma balthica	Baltic Clam	Northern oceans?, NW Atlantic cryptic	Alaska Pacific coast	before 1924	Cryptogenic	Established	Likely	Carlton 1979; Meehan et al. 1989; Cohen & Carlton 1995
Bryozoa								
Alcyonidium "polynoum" or "mytili"	a bryozoan	Unknown (Pacific, NW Atlantic?)	Kachemak Bay	?	Cryptogenic	Established	Unknown	Carlton 1979; Cohen & Carlton 1995; Winston 1999 pers. comm.
Callopora lineata	a bryozoan	Unknown	Prince William Sound	?	Cryptogenic?	Established	Unknown	Foster 1999 pers. comm.; Winston 1999 pers. comm.
Celleporella hyalina	a bryozoan	Unknown	Resurrection Bay	?	Cryptogenic?	Established	Unknown	Foster 1999 pers. comm.; Winston 1999 pers. comm.
Cellepora craticula	a bryozoan	Unknown	Prince William Sound	?	Cryptogenic?	Established	Unknown	Foster 1999 pers. comm.; Winston 1999 pers. comm.
Cribilina corbicula	a bryozoan	Unknown	Prince William Sound	?	Cryptogenic?	Established	Unknown	Foster 1999 pers. comm.; Winston 1999 pers. comm.
Parasmittina trispinosa	a bryozoan	Unknown	Prince William Sound	?	Cryptogenic?	Established	Unknown	Foster 1999 pers. comm.; Winston 1999 pers. comm.

TABLE 8.4 New or Undescribed Species

Species	Common Name	Probable Region of Origin	AK Regions	Date 1st Record	Invasion Status	References
Phaeophyta						
Coilodesme n. sp.	a brown alga	NE Pacific	Prince William Sound	1998	New species	Hansen 1998
Annelida- Polychaeta						
Eumida sp.	a phyllodocid polychaete	Unknown	Prince William Sound	1998	undescribed species?	Kudenoff 1998 pers. comm.
Exogone sp.	a syllid polychaete	Unknown	Prince William Sound	1998	undescribed species?	Kudenoff 1998 pers. comm.
Glycera sp.	a glycerid polychaete	Unknown	Prince William Sound	1998	undescribed species?	Kudenoff 1998 pers. comm.
Nephtys sp.	a nephtyid polychaete	Unknown	Prince William Sound	1998	undescribed species?	Kudenoff 1998 pers. comm.
Polygordius sp.	an archiannelid polychaete	Unknown	Prince William Sound	1998	undescribed species?	Foster 1999 pers. comm.; UAF collections
Scolopos sp.	an orbiniid polychaete	Unknown	Prince William Sound	1998	undescribed species?	Kudenoff 1998 pers. comm.
Mollusca - Gastropoda						
**Adalaria* sp 1.	a nudibranch, Adalaria sp. 1 of Behrens (1991)	Unknown	Prince William Sound	1999	undescribed species?	Goddard 1999 pers. comm.
Adalaria sp. 2	a nudibranch	Unknown	Prince William Sound	1999	Unidentified species	Goddard 1999 pers. comm.
Chordata - Asciiacea						
**Diastaplia* n. sp.	a tunicate	Unknown	Homer, Prince William Sound (Cordova)	1998	New species	G. Lambert 1999 pers. comm.

* This species has been known from West coast of US for several years, but is not yet described (Goddard, 1999 pers. comm.)

TABLE 8.5 Species Range Extensions or First Records for Cook Inlet / Prince Wiliam Sound (sc AK)

Species	Common Name	Probable Region of Origin	AK Regions	Date 1st Record	Invasion Status	References
Rhodophyta						
Polysiphonia senticulosa	a red alga	NE Pacific	Prince William Sound	1998	Range extension	Hansen 1998
Phaeophyta						
Ectocarpus acutus	a brown alga	NE Pacific	Prince William Sound	1998	Range extension	Hansen 1998
Ectocarpus dimorphus	a brown alga	NE Pacific	Prince William Sound	1998	Range extension	Hansen 1998
Chlorophyta						
Codium fragile spp. fragile	a green alga	NE Pacific	Prince William Sound	1998	Range extension	Hansen 1998
Cnidaria-Hydrozoa						
Aequorea aequorea	a hydromedusa	NE Pacific (SE AK)	Prince William Sound, Bering Sea north	1999	First Record sc AK	Mills, Chapt 9C2, this report
Aequorea victoria	a hydromedusa	NE Pacific (SE AK)	Prince William Sound	1999	First Record sc AK	Mills, Chapt 9C2, this report
Clytia gregaria (=Phialidium gregarium)	a hydromedusa	NE Pacific (SE AK)	Prince William Sound, Bering Sea north	1999	First Record sc AK	Mills, Chapt 9C2, this report
Eperetmus typus	a hydromedusa	NE Pacific (SE AK)	Prince William Sound, Bering Sea north	1999	First Record sc AK	Mills, Chapt 9C2, this report
Euphysa sp.	a hydromedusa	NE Pacific (SE AK)	Prince William Sound, Bering Sea north	1999	First Record sc AK	Mills, Chapt 9C2, this report
Gonionemus vertens	a hydromedusa	NE Pacific (SE AK)	Prince William Sound, Bering Sea north	1999	First Record sc AK	Mills, Chapt 9C2, this report
Halitholus sp.	a hydromedusa	NE Pacific (SE AK)	Prince William Sound, Bering Sea north	1999	First Record sc AK	Mills, Chapt 9C2, this report
Melicertum octocostatum	a hydromedusa	NE Pacific (SE AK)	Prince William Sound, Bering Sea north	1999	First Record sc AK	Mills, Chapt 9C2, this report
Proboscidactyla flavicirrata	a hydromedusa	NE Pacific (SE AK)	Prince William Sound, Bering Sea north	1999	First Record sc AK	Mills, Chapt 9C2, this report
Sarsia spp.	a hydromedusa	NE Pacific (SE AK)	Prince William Sound, Bering Sea north	1999	First Record sc AK	Mills, Chapt 9C2, this report
Tiaropsis multicirrata	a hydromedusa	NE Pacific (SE AK)	Prince William Sound, Bering Sea north	1998	First Record sc AK	Mills, Chapt 9C2, this report
Ctenophora:						
Bolinopsis infundibulum	a ctenophore	NE Pacific (SE AK)	Prince William Sound, Bering Sea north	1999	First Record sc AK	Mills, Chapt 9C2, this report
Pleurobrachia bachei (?)	a ctenophore	NE Pacific (SE AK)	Prince William Sound, Dutch Harbor	1999	Range extension N	Mills, Chapt 9C2, this report
Annelida- Polychaeta						
Chaetozone senticosa	a cirratulid polychaete	NE Pacifc	Prince William Sound	1980	Range extension N	Kudenov 1998, pers. comm.
Cirratulus cirratulus	a cirratulid polychaete	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.;
Dodecaria sp.	a spionid polychaete	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.;
Drilonereis falcata minor	a lumbrinereid polychaete	NE Pacific (BC Canada)	Prince William Sound	1980	Range extension N	Kozloff 1987; Foster 1999 pers. comm.;
Drilonereis minor (?)	a lumbrinereid polychaete	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.;
Flabelligera mastigophora	a lumbrinereid polychaete	NW Pacific (Chukchi Sea)	Prince William Sound	1980	Range extension S	Foster 1999 pers. comm.; UAF
Hesperonoe complanata	a polynoid polychaete	NE Pacific	Prince William Sound	1980	Range extension S	Kozloff 1987; Foster 1999 pers. comm.;
Lumbrineris limicola	a lumbrinereid polychaete	NE Pacific	Prince William Sound		Range extension	Kozloff 1987; Foster 1999 pers. comm.;
Lumbrineris luti	a lumbrinereid polychaete	NE Pacific (BC Canada)	Prince William Sound	1988	Range extension N	Kozloff 1987; Kudenov 1998 pers. comm.
Magelona berkleyi	a magelonid polychaete	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.;
Magelona hobsoni	a magelonid polychaete	NE Pacific (BC Canada)	Prince William Sound	1988	Range extension N	Kozloff 1987; Foster 1999 pers. comm.;
Magelona sacculata	a magelonid polychaete	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.;
Mesochaetopterus taylori	a chaetopterid polychaete	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.;
Microphthalmus sczelkowi	a hesionid polychaete	NE Pacific (CA)	Prince William Sound	1980	Range extension N	Foster 1999 pers. comm.; UAF
Mysta barbata	a hesionid polychaete	NW Pacific (Chukchi Sea)	Prince William Sound		Range extension S	Foster 1999 pers. comm.; UAF
Onuphis (=Nothria,	an onuphid polychaete	NE Pacific	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.;
Oriopsis sp.	a sabellid polychaete	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.;

TABLE 8.5 continued

Species	Common Name	Probable Region of Origin	AK Regions	Date 1st Record	Invasion Status	References
Nemidia sp.	a polynoid polychaete	Bering Sea	Prince William Sound		Range extension S	Foster 1999 pers. comm.; UAF
Nemidia tamarae	a polynoid polychaete	Bering Sea	Prince William Sound		Range extension S	Foster 1999 pers. comm.; UAF
Phyllodoce medipalpa	a phyllodocid polychaete	NE Pacific	Prince William Sound		Range extension N	Kozloff 1987; Kudenoff 1998 pers. comm.
Rhynchospio gluteae	a spionid polychaete	Unknown	Prince William Sound		Range extension	Kudenov 1998 pers. comm.
Syllis (Typosyllis) harti	a syllid polychaete	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Foster 1999 pers. comm.; UAF
Syllis (Typosyllis) harti	a syllid polychaete	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Foster 1999 pers. comm.; UAF
Tharyx secundus	a cirratulid polychaete	NE Pacific (BC Canada)	Prince William Sound	1980	Range extension N	Kozloff 1987; Foster 1999 pers. comm.; UAF collections
Mollusca- Gastropoda- Prosobranchia						
Barleeia acuta	Acute Barleysnail	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Kozloff 1987; Turgeon et al. 1988; Foster 1999 pers. comm.; UAF collections
Mollusca- Gastropoda- Opisthobranchia						
Acanthodoris nanaimoensis	Wine-Plumed Spiny Doris	NE Pacific (BC Canada)	Prince William Sound	1999	Range extension N	Kozloff 1987; Turgeon et al. 1988; Foster 1999 pers. comm.; UAF collections; Goddard 1999 pers. comm.
Adalaria jannae	Janna's Adalaria	NE Pacific (BC Canada)	Prince William Sound	1999	Range extension N	Kozloff 1987; Goddard 1999 pers. comm
Adalaria sp.1 of Behrens (1991)	Armed Adalaria	NE Pacific (SE AK)	Prince William Sound	1999	Range extension N	Goddard 1999 pers. comm
Alderia modesta	Modest Alderia	NE Pacific (BC Canada)	Prince William Sound	1999	Range extension N	Kozloff 1987; Turgeon et al. 1988; Goddard 1999 pers. comm
Ancula pacifica	Pacific Ancula	NE Pacific (SE AK)	Prince William Sound	1999	Range extension N	Kozloff 1987; Turgeon et al. 1988; Goddard 1999 pers. comm
Cuthona albocrusta	White-Crust Cuthona	NE Pacific (BC Canada)	Prince William Sound	1999	Range extension N	Kozloff 1987; Turgeon et al. 1988; Goddard 1999 pers. comm
Cuthona pustulata		NE Pacific (BC Canada)	Homer	1999	Range extension N	Kozloff 1987; Turgeon et al. 1988; Goddard 1999 pers. comm
Eubranchus olivaceus	Green Balloon Aeolis	NE Pacific (BC Canada)	Prince William Sound and Cook Inlet		Range extension N	Kozloff 1987; Turgeon et al. 1988; Foster 1999 pers. comm.; UAF collections; Goddard 1999 pers. comm
Geitodoris heathi	Heath's Dorid	NE Pacific (SE AK)	Prince William Sound	1999	Range extension N	Goddard 1999 pers. comm
Janolus fuscus		NE Pacific (SE AK)	Cook Inlet	1999	Range extension N	Foster 1999 pers. comm.; Goddard 1999 pers. comm
	Albatross Aglaja	NE Pacific (SE AK)	Prince William Sound	1980	Range extension N	Kozloff 1987; Turgeon et al. 1988; Foster 1999 pers. comm.; UAF collections
Melanochlamys diomedeum		NE Pacific (SE AK)	Prince William Sound	1998	Range extension N	Kozloff 1987; Foster 1999 pers. comm.;
Melanochlamys ocelliger	Arctic Odostome	Bering Sea	Prince William Sound,Shumagin Is., Kodiak Is.		Range extension S	Berh 1894; Lee & Foster 1985; Foster 1999 pers. comm.; UAF collections
Odostomia arctica	Hansine Seaslug	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Kozloff 1987; Turgeon et al. 1988; Goddard 1999 pers. comm
Olea hansineensis	Banded Polycera	NE Pacific (N to Hawkins Island, Prince William Sound)	Prince William Sound		Range extension W	Foster 1999 pers. comm.; Goddard, pers. comm., 1999
Palio zosterae	Arctic Barrel-Bubble	Bering Sea	Prince William Sound		Range extension S	Turgeon et al. 1988; Foster 1999 pers. comm.; UAF collections
Retusa obtusa						
Mollusca- Bivalvia	Glacial Mussel	Bering Sea	Prince William Sound		Range extension S	Foster 1999 pers. comm.; UAF collections
Musculus glacialis						
Crustacea- Copepoda	Unidentified copepod	NE Pacific (subtropical)	Prince William Sound		Range extension S	Ted Cooney 1998 pers. comm.
Unidentified Calanoid						
Crustacea- Leptostraca						
Nebalia sp.	a nebaliacean	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.; UAF collections
Crustacea- Isopoda						
Gnathia tridens	an isopod	NE Pacific (CA)	Prince William Sound		Range extension N	Foster 1999 pers. comm.; UAF collections

TABLE 8.5 continued

Species	Common Name	Probable Region of Origin	AK Regions	Date 1st Record	Invasion Status	References
Munna chromocephala	an isopod	NE Pacific (WA)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.; UAF collections
Munna ubiquita	an isopod	NE Pacific (WA)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.; UAF collections
Pleurogonium sp.	an isopod	NE Pacific (WA)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.; UAF collections
Synodidotea ritteri	an isopod	NE Pacific (CA)	Prince William Sound		Range extension N	Smith and Carlton 1975; Foster 1999 pers. comm.; UAF collections
Brachiopoda						
Terebratalia crossei	a brachiopod	NW, NE Pacific	Prince William Sound		Range extension N, NE	Foster 1999 pers. comm.; UAF collections
Bryozoa						
Cribilina annulata	a bryozoan	Bering Sea	Prince William Sound		Range extension S	Kozloff 1987; Foster 1999 pers. comm.; UAF collections
Filicrisia smithi	a bryozoan	Bering Sea	Prince William Sound		Range extension S	Foster 1999 pers. comm.; UAF collections
Echinodermata-Asteroida						
Asterias amurensis	Asian Sea Star	NW Pacific; Bering Sea	Homer Spit	1999	Range extension	REFS
Chordata- Ascidiacea						
Chelysoma columbianum	a tunicate	NE Pacific (BC Canada)	Prince William Sound		Range extension N	Kozloff 1987; Foster 1999 pers. comm.; UAF collections
Halocynthia hilgendorfi igaboja	a tunicate	NE Pacific (BC Canada)	Prince William Sound		Range extension	Kozloff 1987; Foster 1999 pers. comm.; UAF collections
Chordata- Osteichthyes						
Sphyraena argentea	Pacific Barracuda	NE Pacific (BC Canada)	Prince William Sound	1998	Range extension	Valdez Vanguard newspaper, 1998

We also considered several reports and specimens that were initially considered as possible NIS, but which we reject primarily as misidentifications of similar native species (Table 8.6).

TABLE 8.6 Species/Specimens Misidentified as NIS

Putative Species	Common Name	Probable Region of Origin	AK Regions	Date 1st Record	Invasion Status	References
Rhodophyta						
Porphyra redidiva	a red alga	NE Pacific	Prince William Sound	1998	Misidentified earlier	Hansen 1998
Chlorophyta						
Monostroma fractum	a green alga	NE Pacific	Prince William Sound	1998	Misidentification, overlooked	Hansen 1998
Angiospermophyta						
Myriophyllum spicatum	Eurasian Watermilfoil	Eurasia	SE Alaska (FW)		Probable misidentification	USGS 1998
Cnidaria-Hydrozoa						
Halitholus sp.	a hydromedusa	NE Pacific	Prince William Sound	1998	Not identifiable to species	Mills, Chap9C2,this rep
Leuckartiara sp.	a hydromedusa	NE Pacific	Prince William Sound	1998	Not identifiable to species	Mills, Chap9C2,this rep
Annelida- Polychaeta						
Anaspio boreas	a spionid polychaete	Gulf of Alaska	Prince William Sound		Uncertain identification	Foster 1999 pers. comm.; UAF collections
Polydora cf. *P. brachycephalata*	a spionid polychaete	NE Pacific (Oregon)	Prince William Sound	?	Misidentification?	Kozloff 1987; Foster 1999 pers. comm.; UAF collections

There are few over-arching ecological traits that characterize marine NIS in Alaska. NIS were variable in their local distributions in the region, with distributions of most species apparently limited to particular sites, but with many sites having some NIS. Although NIS were frequently associated with harbor areas and aquaculture sites, some species (e.g., *Mya arenaria*) occurred widely wherever the appropriate habitat was present. NIS occurred in a wide range of habitats from coastal marshes (*Cotula coronopifolia*) and the high intertidal zone (*Fucus cottonii*) to deep subtidal waters (*Trochammina hadai*), and from variable and low salinity areas (*Mya arenaria*, *Heteromastus filiformis*) to stenohaline high salinities (*Botryloides violaceus*). NIS included species inhabiting hard and soft substrates. NIS also include species from a wide range of motility, from migratory fish to sessile plants and invertebrates; and they included a full range of trophic modes from autotrophs (algae) to suspension feeders to predators. While many of the NIS have life cycles with a dispersal stage (especially echinoderms and bivalves with long-lived planktonic larvae), others had little motility (e.g., sessile tunicates with short-lived planktonic larval stages). Thus, although NIS were most common in habitats most impacted by human activities, there were few sites or habitats within the region and few ecological niches that were immune from invasion.

Although oil tankers transport great quantities of abundant and diverse plankton (including known NIS) into Prince William Sound, we have not identified any established NIS that is clearly attributable to introduction via tanker ballast water. However, analysis of probable transport mechanisms for species introductions is difficult in most regions where multiple transfer agents have been active. In south central Alaska, NIS were commonly found at harbor areas (e.g., Homer), where ballast water and hull fouling associated with cargo ships and the full range of fishing and other vessels are potential vectors. Bulk carriers like wood chip and log ships arriving in ballast to Homer, as well as tankers arriving to Port Valdez, are sources of the largest volumes of ballast water (Smith et al., 1999). Fishing and recreational vessels often have extensive fouling communities which may be transported coastwise within the region. NIS were also found at sites of associated with aquaculture (e.g., Tatitlek) and with fishery introductions

(e.g., Atlantic salmon). Oyster (*Crassostrea gigas*) culture imports spat from Washington and Oregon hatcheries as "clean" seed for grow-up in the field. However, associated parasitic, commensal and fouling organisms frequently could be transported unintentionally with the spat (Carlton, 1992). Similarly, transfer of kelp (*Macrocystis integrifolia*), however "clean" in appearance, from Oregon and Washington (in the past) and southeast Alaska (in the present) could also serve as a vector for many fouling species, epiphytes, or organisms hiding in holdfasts. Several species of fish have been introduced intentionally into Alaskan freshwaters, where they may impact salmonids at key stages of their migratory life cycle. Also, escapes of Atlantic salmon from pen culture have resulted in established populations of *Salmo salar* in British Columbia, as well as in increasingly frequent instances of this NIS fish being caught in Prince William Sound and throughout south central to southeast Alaska.

The number of marine NIS in Alaska appears to be significantly lower than other marine ecosystems along the west coast of North America, where numbers of NIS range from about 50 species in Puget Sound (Cohen et al., 1998) to 250 species in San Francisco Bay (Cohen & Carlton, 1995; Carlton, pers. comm.).

Species Notes:

RHODOPHYTA
Ceramium sinicola- This red alga was found as an epiphyte of *Codium fragile* (*tomentosoides*?) near Green Island. It has not been found previously north of southern California, and is strongly suspected of being an introduction (Hansen 1998).

Chroodactylon ramosum- This microscopic, primitive, red alga was found growing on oyster floats at Tatilek. This species is previously known from Japan, Australia, and southern California (and the Great Lakes, where it was introduced, Mills et al. 1993) but has not been found in the well-studied waters of British Columbia and Washington. It may have been introduced with oysters (Hansen 1998).

PHAEOPHYTA
Fucus cottoni (=muscoides)- This brown seaweed is known from European coasts from northern Spain to Scandinavia (South and Tittley 1986). In the northeast Pacific, it was first found by G. I. Hansen on Vancouver Island in 1981, and subsequently found to be abundant in high marsh and mudflat areas along Prince William Sound (Hansen, 1998; Chapt 9 Hansen). Its status as a separate species has been questioned by Fletcher (1987), who considers this species to be an ecotype of *F. vesiculosus* adapted to marsh and mudflat habitats. Specimens from Prince William Sound have been sent to Esther Serrao, Portugal, who is studying the phylogenetic relationships of *Fucus* using molecular techniques. The widespread distribution of this plant in British Columbia and Alaska, suggests that it is not a recent introduction (Hansen 1998; Chapt. 9 Hansen).

Macrocystis integrifolia- This giant kelp is found from California to southeast Alaska. Since 1979, this kelp had been transported by plane from southeast Alaska to Prince William Sound to be used as substrate for the Herring-Roe-on-Kelp fishery. Blades of kelp are placed in impoundment nets with gravid herring, which deposit their eggs on the kelp. The egg-laden

blades are then harvested and shipped to Japan, as a delicacy. Blades and holdfasts of kelp are commonly found in Prince William Sound, but attached plants have not been found, indicating that this kelp has not become established. While "clean" kelp blades are selected for the fishery, the practice represents a potential vector for transport of microscopic developing stages of algae and invertebrates into Prince William Sound (Jay Johnson, Alaska Fish and Game, pers. comm. to G. I. Hansen ; Hansen 1998). Our examination of several large plants including blades, stipes and holdfasts at Knight Island in the Sound during June 1998 showed that a variety of gastropods, ophiuroids, amphipods and bryozoans were present. It was not clear whether these associated organisms colonized the plants or were present at the time of release into the Sound.

Microspongium globosum- This tiny brown alga is known previously from the North Atlantic and Japan, but it has not been found in the waters of British Columbia and Washington. It grows epiphytically on the cryptogenic brown alga *Demaraeaea attenuata*, attached to oyster floats at Tatilek (Hansen 1998).

Sargassum muticum- This Japanese seaweed was first observed on the U.S. west coast in 1947, in Coos Bay, Oregon. By 1986, it was well established from southern California to southeast Alaska. It was probably transported across the Pacific on the shells of Pacific Oysters from Japan, and then transported along the coast by currents, shipping, and oyster transplants (Scagel 1956; Scagel et al. 1986; Cohen and Carlton 1995; US Fish & Wildlife Service, Nonindigenous Aquatic Species Database 1999).

CHLOROPHYTA

Codium fragile (ssp. tomentosoides?), Dead Man's Fingers- The green algal species *Codium fragile* occurs on the West Coast as a species complex consisting of several unnamed subspecies, presumably native (Cynthia Trowbridge, pers. comm. to G. I. Hansen), as well as the introduced *C. f. tomentosoides.* The latter is native to the Northwest Pacific, and now widely introduced in temperate waters (Farnham 1980; Carlton and Scanlon 1985; Trowbridge 1995). On the West Coast, this seaweed has previously been known only from San Francisco Bay, where it was first collected in 1977, and probably was introduced on ship fouling (Cohen and Carlton 1995). A form of *Codium* nearly identical to *C. f. tomentosoides* was found in 1998, at Green Island, in Prince William Sound, together with a more typically native *Codium*. According to experts on the genus consulted by Hansen, both forms lie within the morphological range of the native populations, but molecular studies will be needed to determine their identity and relationships. In any event, the occurrence of *Codium* in Prince William Sound represents a range extension from southeastern Alaskan waters, and a possible introduction.

ANGIOSPERMOPHYTA

Cotula coronopifolia, Brass Buttons- This attractive flowering plant of the aster family is native to South Africa. It was first reported on the Pacific Coast in 1878, along San Francisco Bay and now occurs in coastal marshes from southern California to southeast Alaska (Hultén 1968; Cohen and Carlton 1995). Brass Buttons was probably transported in the dry ballast of ships to San Francisco Bay and other Pacific ports, as well as to scattered sites on the Atlantic coast of North America and Europe (Hultén 1968). Seeds of this plant (Cohen and Carlton 1995) are a favorite food of waterfowl, which may be how this species reached Alaska.

Additional flowering plants, identified by Hultén (1968) as "introduced weeds" of "waste places" and roadsides, probably occur at the edges of seashores and salt-to-fresh tidal marshes on the Pacific coast of Alaska, based on their habits and distribution elsewhere in North America. The following species are likely to occur in tidal marsh and shore habitats, especially disturbed ones: *Agrostis gigantea* (Redtop); *Polypogon monspeliensis* (Beard Grass); *Puccinellia distans* (Alkali Grass); *Rumex crispus* (Curly Dock); *Rumex obtusifolius* (Round-Leaved Dock)); *Rumex maritimus* (Golden Dock*); Polygonum prolificum* (Prolific Knotweed); *Spergularia rubra* (Sand Spurrey); *Plantago major* (English Plantain) (e.g. Fernald 1950; Gleason and Cronquist 1991; Cohen and Carlton 1995). *Polygonum prolificum* is native to eastern North America; the other species are of Eurasian origin (Hultén 1968). Many of these species were present on the coast of southeast Alaska by 1883 (Meehan 1884), and may have been introduced in ship's ballast.

PROTOZOA- FORAMINIFERA

Trochammina hadai- This foraminiferan is native to Japan, and was first found in North America in San Francisco Bay in 1990-1993 (Cohen and Carlton 1995; McGann and Sloan 1996). It was subsequently found in many Pacific Coast estuaries, from San Diego Bay to Puget Sound (Cohen et al. 1998; McGann 1998 pers. comm.). In San Francisco Bay it forms very dense populations and it processes large amounts of carbon in the benthic communities throughout the estuary. *T. hadai* was also found in EVOS samples taken from deep (300 ft) water of Prince William Sound (McGann 1998 pers. comm.). This benthic protozoan inhabits the sediments (preferably muddy) of brackish-marine estuaries (Matsushita and Kitazato 1990, Kitazato and Matsuchita 1996). It probably has been introduced in ballast water, and was common in sediments in the ballast tanks of oil tankers travelling between west coast ports and Port Valdez (McGann and Sloan 1996; McGann 1998 pers. comm.). However, sediment samples collected from low intertidal to shallow subtidal zones throughout Prince William Sound during 1998-1999 did not contain *T. hadai*, so the extent of this population in the Sound remains unclear (Hines & McGann, pers. comm.).

PORIFERA

Cliona thosina- This boring sponge was originally described in 1888 using specimens on oyster shells from an unknown locality (possibly France or Mexico). *C thosina* was found boring in field cultured oysters (*Crassostrea gigas*) in Prince William Sound in 1998 (Hines, 1998; Ruetzler pers. comm. 1998). Its boring activities weaken oyster shells and can cause shell deformation, breakage and increase vulnerability to predators (such as crabs). The larval stages of C. thosina are short lived (1-2 days), limiting its ability to be transported in ballast water. Oysters cultured in the Sound arrive as "clean" spat derived from laboratory cultures in Oregon and Washington. However, oyster spat is not always as "clean" as the suppliers claim, and many associated species may be found in these types of aquaculture sources (Carlton, 1992). *Cliona* is common in oysters of the lower west coast, so it is possibly derived from these populations.

CNIDARIA- HYDROZOA

Garveia franciscana (Rope Grass Hydroid)- This hydroid has been found in many estuaries around the world, but its origin is uncertain. The Indo-Pacific and the Black--Caspian Sea basin have been suggested as possible native regions (Cohen and Carlton 1995; Calder 1997 pers. comm.) It was first described from San Francisco Bay in 1902, which was its only known location on the west coast of North America (Cohen and Carlton 1995), until we found it near

Homer in 1999 (Lee-Anne Henry pers. comm. 1999; Chapt 9 Fouling Communities). In other regions of the world, this hydroid has been an economically important fouling organism, adversely affecting ships, power plants and fishing gear (Simkina 1963; Andrews 1973; McLean 1972).

ANNELIDA- POLYCHAETA

Heteromastus (filiformis?)- This sediment-dwelling, free-burrowing polychaete, of the family Capitellidae, was first described from Europe, but it is now widely distributed in coastal waters around the world. On the west coast of North America, *H. filiformis* was first reported in 1936, from San Francisco Bay, and subsequently has been found north to British Columbia and Prince William Sound. Its introduction to the Pacific Coast could have occurred with Atlantic or Pacific oysters, or in the ballast water of ships (Carlton 1979; Cohen and Carlton 1995). *Heteromastus "filiformis"*, as with some other capitellid species, may constitute a complex of several morphologically similar species (Cohen and Carlton 1995). *H. filiformis* was collected commonly in Port Valdez in 1971-1972, 7 years after the 1964 earthquake that disrupted the benthic system, indicating that it was established well before initiation of tanker traffic to the Port (Feder et al. 1973).

Lumbrineris heteropoda- This infaunal and polychaete is known from the Sahkalin and Japan, and from two Alaskan specimens, one from Resurrection Bay, and another from Glacier Bay. The wide gap between the known range and the Alaska records is suggestive of an introduction (Nora Foster, 1999 pers. comm.).

MOLLUSCA- BIVALVIA

Crassostrea gigas (Pacific Oyster; Japanese Oyster)- The Pacific Oyster was first planted in North American waters in 1902, in Puget Sound. By 1939, it was cultivated in Ketchikan, Alaska, and it is now reared in Prince William Sound, Katchemak Bay and other locations. Alaskan waters are too cold for natural reproduction of *C. gigas*, so spat must be transferred from southern waters (Quayle 1969; Carlton 1979;R. Piorkowski 1999 pers. comm.).

Mya arenaria (Softshell Clam)- The Softshell Clam has a complex biogeographical history. This species evolved in the Pacific, in the Miocene Period, and subsequently invaded the Atlantic, but became extinct in the Eastern Pacific (Strasser 1999). Living populations of *Mya arenaria* remain in the Bering Sea, but on the Eastern Pacific Coast, shells of softshell clams are absent from subfossil deposits and shell middens, including those recently examined for *M. arenaria* (Foster, Chapt 9C7, this report). *Mya arenaria* was re-introduced to the Pacific Coast in San Francisco Bay in 1874, probably with plantings of Eastern Oysters (*Crassostrea virginica*). It was soon widely transplanted along the coast, reaching Alaska by the 1960s-1970s (Carlton 1979). The clam has been widely established for decades in Prince William Sound and Port Valdez (Feder et al. 1973, Feder and Paul 1973), and was heavily impacted by benthos upheaval in the 1964 earthquake (Baxter 1971).

CRUSTACEA-AMPHIPODA

Jassa sp.; *Jassa marmorata*- A tube-dwelling amphipod of the genus *Jassa* from Prince William Sound was found in University of Alaska collections (Nora Foster pers. comm.). Specimens are being examined by John Chapman, but are not yet identified to species. *Jassa marmorata*, native

to the northwest Atlantic, has been widely introduced in the world's oceans, and has been collected from Alaska waters (Point Slocum, Conlan 1989; Cohen and Carlton 1995; Chapman 1998 pers. comm.). Amphipods of this genus build tubes on hard surfaces, including ship hulls, but also have been collected from ballast water (Cohen and Carlton 1995).

BRYOZOA

Cryptosula pallasiana- This bryozoan is apparently native to the Atlantic Ocean, but is now widely distributed in the Pacific. An early (1925) record of *C. pallasiana* from Homer, Alaska was a misidentified specimen of *C. okadai*, but in 1944-46 it was found in Sitka (U. S. Navy 1951; Carlton, pers. comm.), as well as San Francisco Bay, and Newport Harbor, California. It was probably transported in ship fouling (Cohen and Carlton 1995).

Schizoporella (unicornis?)- This northwest Pacific bryozoan was first collected in the Eastern Pacific in 1927, in Puget Sound (Carlton 1979; Cohen and Carlton 1995). Its first Alaska collection was made between 1944 and 1949, in Kodiak (U. S. Navy 1951; Powell 1970; Dick and Ross 1988; Carlton, pers. comm.). *Schizoporella unicornis* may have been introduced in ship fouling or with plantings of Pacific Oysters (Cohen and Carlton 1995). In 1999, it was found in Tatitlek. (This form, while definitely introduced to the Pacific coast, may actually be a complex of several species (Winston 1999 pers. comm.).

ECHINODERMATA- OPHIUROIDEA

Ophiothrix koreana- A single brittlestar from Southeast Alaska (Juneau) has been tentatively identified as *O. koreana (*Kyte 1998, pers. comm.). If this identification is correct, this collection would be the first record of this northwest Pacific ophiuroid from the eastern Pacific. Since only a single specimen has been collected, the existence of established populations is unknown. Most brittlestars have long-lived planktonic larvae, so ballast-water transport is likeliest, but transport with oysters or ship fouling can not be ruled out.

CHORDATA- ASCIDIACEA

Botrylloides violaceus (=*Botryllus aurantius*)- This colonial tunicate is native to the northwest Pacific (Japan), and may have been first found on the West Coast in 1973, in San Francisco Bay (Cohen and Carlton 1995). It is now widespread, from southern California to British Columbia (Cohen et al. 1998; Lambert and Lambert 1998). *Botrylloides violaceus* was abundant on fouling plates in Prince William Sound in 1999 (G. Lambert 1999 pers. comm.).

CHORDATA-OSTEICHTHYES

Alosa sapidissima (American Shad)- This anadromous fish, native to the Atlantic coast of North America, was introduced in 1871, to the Sacramento River. It rapidly spread along the Pacific coast, and was first collected in Alaska in the Stikine River in 1896. Shad spawn in freshwater rivers from San Francisco Bay, north to the Columbia River, but feeding adult and juvenile fish wander as far north as Cook Inlet and the Kamchatka Peninusla (Chapman 1942; Cohen and Carlton 1995). A specimen of this species from Port Moller, Alaska Peninsula resides in the University of Alaska Museum collections (Foster 2000, pers. comm.). American Shad have been captured by seines and gill nets in Southeast Alaska during strong El Niño years, e.g., 1969 and 1983 (J. Karinen, 2000 pers. comm.)

Dallia pectoralis (Alaska Blackfish)- This small freshwater fish is native to the North slope and Yukon-Kuskakwim Delta of Alaska and eastern Siberia, but it was introduced in 1950 to Hood and Spenard Lakes in Anchorage, in the Susitna River drainage, and has spread to other lakes in the vicinity (Morrow 1980). We are unaware of records of this fish in brackish or tidal waters, but we are including it here because of concerns of adverse impacts on Rainbow Trout (*Oncorhynchus mykiss*) and other salmonid populations in the Anchorage area (Morrow 1980).

Esox lucius (Northern Pike)- This large predatory, freshwater gamefish is native to most of the glaciated regions of North America and Eurasia (Scott and Crossman 1973). In Alaska, the native range includes the Bering Sea drainage, and North Slope, but not Pacific watersheds. Northern Pike were illegally introduced to the Susitna River valley in the 1970s (Morrow 1980). This species is known to enter brackish waters (Scott and Crossman 1973), though we are unaware of estuarine occurrences in Alaska. Pike have a reputation as predators of salmonids, so their introduction has long been discouraged on the West Coast (Lampman 1946; Dill and Cordone 1997).

Salmo salar (Atlantic Salmon)- Atlantic Salmon are native to both sides of the North Atlantic, and spawn in rivers of Europe and eastern North America. Many unsuccessful attempts were made to stock this species on the West Coast, beginning in the Sacramento River in 1874 (Dill and Cordone 1997), but the extensive use of *S. salar* in net-pen aquaculture has again raised the possibility of its establishment in Pacific waters. Rearing of Atlantic Salmon is illegal in Alaskan waters, but occurs in British Columbia and Washington (USGS, Nonindigenous Aquatic Species Database 1999). In Alaska, the Atlantic Salmon was first caught off Cape Cross, in southeastern waters, in 1990 (Wing et al. 1992). Since then, many *S. salar* have been caught in the state's marine waters, and in 1998, the first one was caught in Alaska freshwater (Freeman 1998 pers. comm.; USGS, Nonindigenous Aquatic Species Database 1999), and some have been caught in Prince William Sound with landings reported at Port Valdez and Cordova (Benda 1997 pers. comm., Freeman 1998 pers. comm.). Many escaped cultured fishes are in poor condition (USGS, Nonindigenous Aquatic Species Database 1999), but successful reproduction has been documented on Vancouver Island (Volpe 1999), and could well occur in Alaska waters.

Salvelinus fontinalis (Brook Trout)- This eastern North American fish was introduced into southeast Alaska in the 1920s, and continued to be stocked into the 1950s. In its native range, the Brook Trout has anadromous populations in coastal regions, from Massachusetts to Labrador (Morrow 1980). We have not found documentation of sea-running fish in Alaskan waters, but estuarine occurrences of this trout are possible. However, few populations occur in coastal lakes, and none are known from streams or rivers (Alaska Department of Fish and Game 1994) The Brook Trout may hybridize with the native Dolly Varden, but the impact of this crossing on native populations is unknown (Morrow 1980).

Suspicious Species

ECHINODERMATA- ASTEROIDEA
Asterias amurensis (Common Asian Sea Star)- This sea star is native to the Northwest Pacifc, including the coasts of Japan and Russia north to the Tatarskii Inlet and the southern Kuril Islands, and to the Bering Sea Coasts of Russia and Alaska (Baranova 1976; Ward and Andrew

1995, Jewett and Feder 1981). Its recent appearance at Homer in Cook Inlet could represent a natural range extension. However, this species has long-lived planktonic larvae and could also be carried in ship ballast water. *Asterias amurensis* has successfully invaded the coast of Tasmania, where it poses a threat to shellfisheries (Ward and Andrew, 1995). Shipping traffic into Homer by bulk carriers of logs and wood chips increased markedly recently as spruce trees killed by a beetle outbreak have been forested. These ships probably bring large quantities of ballast water to Homer from Asian ports within the established of range *A. amurensis*. The recent appearance of *A. amurensis* in the low intertidal zone at the tip of Homer Spit was noted as a sudden arrival by experienced naturalists (C. & C. Field, 1999 pers. comm.), who have been studying the area for several years. This large conspicuous sea star would not be overlooked easily and was not recorded previously in the many benthic trawl surveys of the Gulf Alaska (N. Foster, UA Museum 1999 pers. comm.). Specimens of *A. amurenis* are not represented in the University of Alaska Museum's collections for trawl surveys in either the Gulf of Alaska (Foster, 1999 pers. comm.) or Cook Inlet (Feder and Paul 1981, Feder et al. 1981). The survey of Cook Inlet also included scuba surveys. It would have been very unusual for such collections to miss a large conspicuous sea star (30 cm from ray tip to ray tip). We consider this species to be cryptogenic in Cook Inlet, with characteristics that are very suspicious of an NIS. Because it is a voracious predator, it could have a major impact on benthic communities.

ASCIDIACEA

Distaplia n. sp.- This tunicate is a new, undescribed species (G. Lambert, 2000, Chapt 9C10, this report), which is very abundant in fouling communities on floats and man-made substrates in marinas at Homer and Cordova. It was first collected in 1998 in Homer and was found in both Homer and Cordova in 1999. It was not found at other sites within Prince William Sound where other, native species of tunicates were common in fouling communities but lack similar shipping/boating traffic (e.g., Tatitlek, Chenega, Port Chalmers). These sites were sampled by the same expert taxonomists and systematists who found the species at Homer and Cordova. Also, sites with and without the new species were sampled at the same times with an equivalent sampling effort (fouling plates, Chapt 9D, this report). Its appearance is also suspicious, because it was not identified in 1901 when tunicates were collected in the region at nearby sites (Ritter 1903), but this ascidian taxonomist tended to "lump" species of *Distaplia* (G. Lambert, 1999 pers. comm.). This tunicate could be a formerly rare native species that has taken advantage of the newly created marina habitat (G. Lambert 1999 pers. comm.), or a recent introduction.

CRYPTOGENIC SPECIES

PHAEOPHYTA

Demaraeaea attenuata- This is a possible introduction from the Northwest Pacific, but G. Hansen treated this alga as cryptogenic, although she considered its epiphyte *Ceramium sinicola* to be a more likely introduction (Chapt 9C1, this report).

ANGIOSPERMOPHYTA

Atriplex patula & A. prostrata- These flowering plants commonly occur on marshes and beaches, but Hultén (1968) refers to them (lumped as *A. patula*) as an "introduced weed". Botanists are divided on their status in North America, and on the East Coast they can be traced back to the early 1700's. Here, we designate them "cryptogenic".

ANNELIDA-POLYCHAETA
Capitella capitata and other polychaete species complexes- Many cosmopolitan polychaete "species" are believed to represent groups of sibling species, with little morphological differentiation, but possibly with differing life histories and environmental adaptations. This has been shown for the pollution-tolerant worm *Captitella capitata* (Grassle and Grassle 1976), and is suspected for many others. Cryptic invasions by foreign sibling species could be common for species with planktonic larvae, especially in newly polluted harbors, where less-tolerant natives could be replaced by better adapted invaders. Such invasions could only be detected by genetic methods, or by very exacting morphological studies.

Polydora quadrilobata- This spionid polychaete has a wide distribution, including both sides of the North Atlantic, the Northwest Pacific, and the Northeast Pacific coast from California to Puget Sound (Blake 1971; Kozloff 1987). At least 7 species of spionids have been introduced to the Northeast Pacific (Cohen and Carlton 1995; Cohen et al. 1998). Foster (N. Foster, UA Museum, 1999 pers. comm.) considers *P. quadrilobata's* wide distribution to be suspicious, in view of the numerous introductions of this group: "The suspicious designation results from my perception that Spionidae do seem to make up a large proportion of the NIS listed by the Puget Sound expedition."

BRYOZOA
Alcyonidium (polyoum?) Native and introduced cryptic species are presumed to exist on the Pacific Coast. However, Alaska animals may be more likely to represent native forms, while San Francisco Bay bryozoans are more likely to be introduced (Cohen and Carlton 1995).

MOLLUSCA- BIVALVIA
Macoma balthica- Native and introduced cryptic species are presumed to exist on the Pacific Coast. However, Alaska animals may be more likely to represent the native forms (Meehan et al. 1989; Cohen and Carlton 1995).

CRUSTACEA-COPEPODA
Leimia vaga- This benthic harpacticoid copepod was first described from Nova Scotia, but has a limited distribution in the North Atlantic and is found in several Oregon and Washington estuaries (Chapt 9C5; Jeff Cordell 1999 pers. comm.). In 1999, our surveys found it in Prince William Sound (Chapt 9C5, this report). Its disjunct distribution is suggestive of transport between coasts, but the origin of this species is unknown.

8D. Conclusions

We have identified 24 species of plants and animals comprising the NIS of marine related ecosystems in Alaska, including 15 species recorded from Prince William Sound. In addition, 2 cryptogenic species have highly suspicious characteristics of NIS. These species represent a diverse array of taxa that occupy a wide range of ecological niches and habitats, although there appear to be more NIS associated with boat harbors and with aquaculture activities. Several of these NIS are first records for Alaska. We also recorded several new, previously undescribed species as well as numerous range extensions for species, which probably reflect the poor level of study and understanding of taxonomy and biogeography in Alaskan marine ecosystems. Many of the Alaskan NIS have larval stages which could be transported in ballast water; however,

other vectors (including intentional and incidental release for fisheries and aquaculture) are obvious possibilities. None are clearly associated with ballast water of oil tankers as a primary mechanism, even though many NIS are frequently found in ballast water arriving to Port Valdez (see Chapt 3, this report). The number of marine NIS in Alaska appears to be significantly lower than other marine ecosystems along the west coast of North America, where numbers of known NIS range from about 50 to 250 species. The complexities and uncertainties of the native biota and the history of vectors in the south-central Alaskan region will inevitably result in an evolving analysis, typically revealing previously hidden importance and impacts of NIS.

8E. References

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